CHAPTER 13

INSTRUMENTATION, CONTROL, COMMUNICATIONS, AND FIRE DETECTION AND ALARM SYSTEMS

13-1. GENERAL. Design requirements for instrumentation, process controls, communications, and fire detection and alarm systems are provided in this chapter. In this engineering discipline effective systems are designed that provide a means of measurement, control, and monitoring of facility systems and equipment. It is of prime importance that drawings, specifications, and technical direction are compatible with design requirements, and that graphic symbols, shapes, and equipment identification used in the drawings are the same among all designers. This is especially critical if the graphic symbols used to represent devices (flow lines, signals, remote/local functions, etc., between different disciplines) which, if misinterpreted, lead to dangerous conditions to personnel or equipment.

13-2. PURPOSE AND APPLICABILITY. The purpose of this chapter is to ensure that designs provide a firm basis for obtaining equipment and systems which are operable, maintainable, measurable, cost effective, and technically sound. This chapter also provides a uniform method for monitoring and control of facility equipment to ensure that the quality of the equipment and systems are not degraded by use or time. The requirements contained in this chapter apply to all designers, A-E's, and contractors for use in developing, monitoring, and controlling functions for large and complex facilities and data handling systems for which USAEDH has design responsibility. It is suitable for use with all engineering disciplines whenever instrumentation, control, and communication functions are needed.

13-3. REFERENCE DOCUMENTS

a. AMCR 385-100, Safety Manual

b. ISA-S5.1, Instrument Symbols and Identification

c. ER 1110-3-110, Information Systems Design for Support of Military Construction

d. ETL 1110-3-433, Federal Information Processing Resources in Military Construction Projects

e. FM 11-486-5, Telecommunications Engineering Outside Plant Telephones

f. MIL-C-17, Cables, Radio Frequency, Flexible and Semi-Rigid

g. MIL-HDBK-1008B, Fire Protection for Facilities Engineering Design and Construction

h. TM 5-811-9, Voice/Data Telephone System

i. Electronic Industries Association (EIA) Publications

j. Insolated Cable Engineers Association (ICEA)

k. Institute of Electrical and Electronic Engineers (IEEE) Standards

l. National Fire Protection Association (NFPA) Publications

m. Rural Electrification Administration (REA) Publications

n. Underwriters Laboratories (UL) Publications

13-4. ENGINEERING INSTRUCTIONS

a. Communications. Communications design will include telecommunications, paging, video, and intercom systems to the extent required by the project criteria.

(1) Designers will coordinate with the communications officer the design requirements of all systems involving interface with the installations communications network or use of a radio frequency.

(2) In situations where a telecommunications net will be providing data support for devices such as facsimile, teletype, computer peripherals, and support among computers, the appropriate telecommunications equipment must be specified by the designer. Specifications should include data rate, appropriate EIA standards, and MODEM characteristics.

(3) Intercom, paging, and master antenna television systems design must be based on available guide specifications.

(4) Closed-Circuit Television.

(a) Camera specifications should include:

1 Sensitivity range in foot-candles.

2 Compatibility with lighting, such as high pressure sodium, incandescents, etc.

3 Resolution.

4 Camera requirements including controls.

5 Focus requirements.

6 Pan, tilt, and zoom desired.

7 Enclosure requirements.

(b) Video Monitors. Video monitors will be compatible with the cameras. Displays should not introduce any visible picture distortion or audio distortion into the reproduced video signal at input signal levels of 1000 microvolts or greater. As a minimum, the display will include front panel on-off, volume and brightness controls, and will be adjustable for normal viewing under background lighting conditions of 50-100 footcandles.

(c) Recorders. Where a video tape recorder is required, cassette type with audio, display, and search features will be specified. Recorders will be commercial grade. In

systems with multiple video monitors, operators should be able to select the video monitor to be recorded.

(5) The communication systems design will include raceways, devices, cables, and terminal cabinets inside plant layout, riser, and single-line concept. Fiber optic cable will be provided throughout the facility per policy (see applicable US Army Information System Command (USAIC) cable policy). The design size of the raceways, number of bends in conduit, and the maximum length of conduit run will be IAW the guide specifications and NFPA and EIA standards. Raceway supports and fasteners will conform to the requirements specified in chapter 8, Electrical Power Supply, Distribution, and Utilization Systems.

(6) Communication terminal cabinets will be provided by designers as required by the NEC for the area in which the cabinet is installed and will comply with UL-50. The cabinets will normally be wall-mounted and be provided with a 15.0-mm (5/8-inch) or 18.0-mm (3/4-inch) thick weatherproof plywood backboard. The size and mounting of the backboard will be IAW the guide specifications and drawings. Inside cable and outside trunk cables will be divided in the backboard and cross connects will be spaced accordingly.

b. Process Control Equipment. Since safety is a paramount design consideration, designers will specify controlled devices with a device setting which minimizes the overall system impact when control system failure occurs. Controlled devices critical to system operation will be provided with a control mode, such that a failure in a control system will automatically transfer to the manual or fail-safe mode as required for safe system operation.

(1) For an automated operation, the time interval between receipt of a complete set of input data and the implementation of a control command based on the input data should be less than one-half the nominal response time of the process or equipment being controlled.

(2) The automatic control system should initiate and safely shutdown equipment when an alarm or data indicating unsafe or self-destructive operation is detected.

(3) All equipment containing volatile memory should cycle "self-test" data to verify the integrity of the circuitry and system operating programs.

(4) Designers will specify the size of control valves for a normal flow at no more than 70% of the capacity of the valve.

c. Control of Rotating Machinery. Automatic shutdown systems will be kept to a minimum. Automatic shutdowns should only be furnished to protect machinery from malfunctions which cause personnel hazard or rapid and extensive equipment damage.

(1) If loss of power or shutdown occurs, each component in the control system and the safety shutdown system must assume a condition that minimizes personnel hazard and equipment damage.

(2) An alarm should precede each shutdown to allow time for operator action. The design will require a separate alarm at shutdown to identify the source of shutdown. The sequence is alarm, then alarm and shutdown. If shutdown occurs, the machine will remain locked out until manually reset. All alarm circuits and shutdown circuits should be normally energized, i.e., the alarm sound or shutdown initiation occurs when the circuit is de-energized. A

backup power system will be provided for all alarm and circuits as backup power when the primary power source is lost.

(3) The designs will require that rotating machinery be shut down by interrupting the source of energy to the driver.

(4) Normally, a voting system is used to initiate shut-downs in the event of high axial displacement and high radial vibration. In a voting system, sensors are installed in pairs. When either signal reaches the alert level, an alarm is given. When both signals reach the critical level, an alarm is given and the machine is shut down.

d. Alarms. Alarms are defined as those audible and visual signals for alerting operating personnel of the need to take corrective process action or to be advised of an operating condition which is deviating from preset limits.

(1) Designers will assign priorities to alarms such that those which affect safety or critical components will be reported first. Alarm reporting time will be specified.

(2) Alarms should operate under the same condition as the equipment they protect. For example, if equipment continues to operate through power failure, its associated alarms must also operate through power failure.

e. Instrumentation. Process and instrumentation diagrams, drawings, symbols, and associated descriptions will be IAW ISA-S5.1. Also refer to appendix J, Equipment Major, Minor Measurements, of this document.

f. Cables. When cable requirements are not included in applicable guide specifications then:

(1) Transmission lines for instruments and transducers will be grouped together and run in multiconductor cable. Multiconductor cable will have an overall shield. Individual twisted pairs will be shielded when required to minimize cross- coupling between signal lines. All wire pairs will be twisted with at least eight twists per foot. Multiconductor cables will have color coded wires. Cable should be chosen to conform to the appropriate REA or ICEA standard.

(2) In some locations, shielded cables, coaxial cables, and d.c. power cables will be required. These cables will be standard type and will generally comply with the requirements of MIL-C-17.

(3) Designers will follow the manufacturers' recommendations when special equipment wiring, such as for turbine meters is required.

(4) All cabling will be designed for a minimum 20-year life and include spare capacity.

(5) The design data sheets describing cable construction and characteristics will be included in the specifications.

g. Instrument Wiring

(1) Signal returns and shields should be grounded at one end only.

(2) Signal wiring will be separated from power wiring and electrical equipment to minimize noise. Crossovers between power and signal wiring should be made at right angles whenever possible. Signal wiring will not be run in the same conduit tray with power wiring.

(3) Where a strong magnetic field is known to exist, signal wiring will be routed to minimize interference (parallel to the magnetic flux lines).

(4) Signal wiring should not normally be routed through areas where ambient temperatures exceed 80 degrees C (176 degrees F).

(5) Designers will specify mounting instrument panels and enclosures so that they are self-supporting, shock isolated, and free of vibration problems. Mounting surfaces will be smooth and blemish free. Front and rear spacing should allow free access for maintenance functions, where required.

h. Instrument Features

(1) Designers will specify the construction materials for instruments or instrument parts that come in contact with process fluids. These construction materials will conform to material specifications of the process line or equipment, except where the design features of an instrument limit the use of certain construction materials.

(2) Electrical construction of instruments is determined by the location or occupancy as defined by the National Electrical Code covering hazardous locations.

(3) Designers will select scales and ranges for instruments to meet the application. As a general rule, the scale or display range should be chosen so that the expected value of the measured variable will fall between 60% and 80% of full scale.

(4) Analog transmission of transducer data will be via standard 4-20 milliampere current loop, unless technical considerations dictate otherwise.

(5) Equipment must be protected from power line surges. Designers will refer to either IEEE-STD-472 for providing protection against surges. Maximum protection must be sized according to the largest Joule rating and lowest clamping level available for the application. Protection will be provided near equipment and, as necessary, at the power panel to ensure protection against surges.

i. Display Devices. Indicators, display devices, and recorders are functions that may be accomplished by dedicated hardware, a Cathode Ray Tube (CRT) display terminal, or a combination of both. CRT display terminals and peripheral hard copy devices will be used where flexibility is desired, or if the system is large and complex.

(1) Monitoring, control, and data handling panels in subsystem areas and at a main central location will be provided as required. The centrally located equipment will receive status signals and data signals from local subsystems. The status of the various subsystems will be visually displayed. The central location will control specified equipment in the various subsystems locations.

(2) Status indication and data readouts on local panels within the immediate vicinity of the operating equipment and at the centrally located panel will be provided as required.

(3) Status annunciator panels will have individual indicators with a legend describing the associated point. Panels will be backlighted. Systems or equipment in operation and performing within defined tolerances will be identified by a green light. Systems or equipment operating or performing out-of-tolerance will be identified by a red light.

(4) The Monitoring and Control System (M&CS) will include printers and strip chart recorders required to log the systems operation. The equipment provided for the recording function will permit periodic or continuous recording as selected by the operating personnel. The equipment will immediately record the receipt of an off-normal signal.

(5) Every analog or digital point in the system will be available for display. Set point, output, and control modes will be manipulated through the display. Critical procedures will be restricted from inadvertent operator action through use of a key-lock.

(6) Out of tolerance values will be displayed by a blinking representation. If a color CRT display terminal is specified, the color of abnormal values and alarm values should be specified (red is recommended for alarms).

(7) Historical trend of any point on the screen should be available for selection and display on command. The historical trend display will represent the trend on operator selectable time-bases. The historical display will be updated with real-time values automatically.

(8) At least one printer will be provided for hardcopy of display information to include alarm, logging, and trending. If graphics are used with the CRT display terminal, then a hardcopy device will be specified which will reproduce the graphic display.

j. Termination Equipment

(1) Terminal cabinets will be as required by the National Electrical Code for the area in which the cabinet is installed and will comply with UL-50. The cabinets will normally be wall-mounted.

(2) Terminal blocks used for terminating instrumentation cables will be chosen, where needed, to be suitable for the environment and purpose.

(3) Terminal block marking strips will be made of laminated plastic. The marking strips will be engraved and 3.0-mm (1/8-inch) thick.

(4) The terminal block types, shield terminal types, and conductor terminal types will be in accordance with the applicable guide specifications or project requirements.

13-5. DESIGN AND INSTALLATION. The design of the facilities and the performance of the installation work will be IAW the guide specifications, drawings, military handbooks, AMCR 385-100, and other industry standards as designated by the scope of work. Design and installation of facilities used for processing classified information will be IAW applicable Department of Defense documents. The design of the facilities will be in sufficient detail to allow repetitive construction of future facilities from one set of drawings and to limit the amount of layout engineering required by the construction contractor.

13-6. SUPPORT FACILITIES

a. Exterior

(1) Raceways. Underground raceways will be duct or rigid steel conduit as required for the particular installation. Underground duct, if used, will be concrete- encased cement, fiber or plastic type. The raceways will be 100.0 mm (4 inches) inside diameter unless otherwise specified. The spacing between raceways will be at least 50.0 mm (2 inches). If concrete encasement is used, the thickness of concrete between the outside of the duct and the edge of the concrete envelope will be 75.0 mm (3 inches minimum). Raceways will be installed a minimum of 600.0 mm (2 feet) below grade. The raceways will drain into manholes on a slope of 3 mm per meter (3 inches per 100 feet), either from a high point in the run or from manhole to manhole. A careful study should be made to ensure that proposed installations will not conflict with other utilities in the construction area. Raceways will be designed to protect wiring from static electricity effects, where this requirement is applicable.

(2) Manhole types will be IAW standard drawings unless other types are indicated in the contract. Minimum floor to ceiling height of manholes is 1.8 m (6 feet). Stubs for future extension will be provided at all unused entrances. Maximum straight-run distance between manholes for installing cables is 225 m (750 feet). Where raceway systems contain both communication and power cables, the maximum spacing between manholes will be governed by the power cables. Separation between communication and power raceways will be 90.0 mm (3 1/2 inches) minimum. Dis-tance between manholes on curved sections should be more limited than for straight runs. Standard specifications will be available for manholes and duct banks. These specifications may include a requirement that the construction contractor provide, through the services of a registered professional engineer, a staking sheet to include a profile of the raceway system. A plan layout is required from the A-E and should be carefully reviewed to determine that the required depths, grades, dimensions, and locations can be obtained in the areas where the system and manholes are shown.

b. Interior. Raceway systems will be designed in accordance with EIA/TIA 569, Commercial Building Standard for Telecommunication Pathways and Spaces. Cable trays will be constructed of high-strength, corrosion-resistant aluminum alloy or will be hot-dipped galvanized steel as required by the criteria. Cable trays will provide at least 85 mm (3-3/8 inches) minimum clearance inside depth for cables. The width of the trays will be spaced on 2 m (6-foot) (maxi-mum) centers unless otherwise specified. The cable trays and support systems will support a load of at least 1460 newton per meter (100 pounds per linear foot). Maximum deflection will not exceed 6.35 mm (0.250 inch) when considered as a continuous beam.

(1) The cable tray system design will be complete with standard and/or special factory fittings, horizontal and vertical bends, crosses, tees, reducers, dropouts, end plates, and supports as required for a complete installation. Fittings and supports will be shown on the detailed cable tray layouts on the drawings.

(2) Rungs of cable trays will be bonded to each side channel.

(3) Cable trays will be grounded. Each run of cable tray will be grounded at 30 m (100-foot) maximum intervals. Copper-to-aluminum connections will be made by approved bimetallic connectors.

(4) Conduits will be installed in accordance with the National Electrical Code, Article 346. Conduits will be rigid steel or electrical metallic tubing, depending on the design requirements.

13-7. SPECIAL CONTROL, SIGNAL, OR ALARM SYSTEMS. The concept and final specifications will describe the proposed overall function of the system. Final specifications will also include detailed specifications for each of the major components of the system.

13-8. FIRE ALARM AND DETECTION SYSTEMS

a. Where Used. Fire alarm and detection systems will be installed in buildings where fire hazards exist and in buildings containing equipment that justifies the cost of a fire alarm and detection system.

b. Type. The fire alarm and detection system will be the local, supervised, automatic or manual, noncoded type with separately mounted coded system transmitter for signaling a central fire station when required by design criteria.

c. Activation. The systems will be designed so that the activation of a manual station, automatic detector, or sprinkler system, or any other systems will cause audible and visual alarms to activate instantly and will cause the transmitter to send a code over the base fire alarm transmission systems to the central fire station.

d. Basis of Design. Designs will conform to the applicable portions of Military Handbook 1008B, Corps of Engineers Guide Specifications, and to the specific contractual requirements of the project. Information pertaining to fire alarm and detection systems will be included in the Fire Protection Design Analysis specified in chapter 1.

e. Surge Protection. Fire protection communication circuits leading to a central receiving console will be protected at both ends against surges. This requirement will apply for circuits that are routed both in underground conduits and aerial construction. In addition, EMI-generated by lightning or other sources will not produce false alarms or other undersirable effects.

f. Signal Initiation Devices. These devices (smoke detectors, etc.) will be provided in stairwells, hallways, and as specified by NFPA and the CEHND Safety Engineer.

g. Fire Alarm. A complete separate riser diagram will be shown for each fire alarm system and will include:

(1) Power supply.

(2) Control panel and associated equipment.

(3) Manual and automatic stations.

(4) Audible and visual alarms.

(5) Conduit runs, including number of conductors and conduit size.

(6) Coded transmitter.

(7) Remote annunciator if required.

(8) Connection to base fire alarm systems.

(9) Spare entrance conduit for future connection to base fire alarm systems.

(10) Zones if not an addressable system.

h. Other Signal or Alarm Systems. A separate one-line diagram will be shown for each separate system and will include:

(1) Power supply.

(2) Control panel or device.

(3) All other components.

(4) Conduit runs.

i. Panelboard Schedules. Panelboard schedules will be shown for each alarm system.

13-9. REQUIREMENTS FOR PLANS. Plans will contain the following:

a. Floor Plans. The floor plans will show all principal architectural features of the building that will affect the design.

(1) Room designation and number.

(2) Dimensional height, location, number, and size of raceways.

(3) Dimensional height, location, size, and designation of cabinets, outlet boxes, etc. Plans should clearly indicate type of mounting required (flush or surface, wall or floor).

(4) Conduit and cable routing and numbers.

(5) Dimensional size, location, space requirements, and designation for all control consoles, instrumentation panels, control and monitoring panels, power supplies, fire detection and alarm equipment, etc.

(6) Grounding requirements.

b. Riser Diagrams. A complete separate riser diagram will be shown for each telephone, paging, intercom, fire detection and alarm, and instrumentation system (data transmission, monitoring and control, auditory and visual warning, annunciation, etc.).

(1) Size, type, and number of cabinets, junction boxes, outlets, devices, etc.

(2) Size, type, and number of cables and raceways.

(3) The location of all components, such as cabinets, consoles, outlets, power supplies, control panel (central and local), manual and automatic stations, and annunciators will be clearly indicated.

(4) Connections to other systems (such as power supply, signal transmission to remote location, etc).

c. Schedules. Conduit and cable schedules will be shown and will show conduits and cables installed. The schedule will contain the number, type, size, originating point, destination point, and termination requirements for each conduit and cable.

d. Connections. Connection details will be shown for each cabinet or console in which cables are terminated. The connection details will show the outline of the cabinet, location of terminal blocks in the cabinet, type of terminal blocks, termination of conductors on the terminal blocks, type of terminals used to terminate the cables, and any grounding required. The termination of shields, if used, will also be shown.

e. Construction. Construction details and complete dimensions will be shown for each cabinet. The details will show the outline of the cabinets, thickness of the metal, mounting of internal equipment such as channel support, location of all openings in the cabinet, mounting and securing of doors, and other pertinent features.

f. Sections and Elevations. Details, sections, and elevations will be shown where required for clarifications.

g. Equipment by Others. The drawings will indicate equipment furnished and/or installed by others.

13-10. SPECIFICATIONS. The final specifications will be prepared as required in chapter 3, Project Specifications, and will cover instrumentation, control, and communication work to be accomplished. Specifications will be in one or more sections as required by the nature of the work. All design data sheets for cable construction will be contained in an appendix to the applicable section of the specifications. Supplemental paragraphs should be included, as applicable, to augment the guide specifications and should completely describe or specify the materials, equipment, and/or project requirements. Portions of guide specifications not applicable to the project will not be included in the final contract specification.

a. Conflicts. Care must be exercised to prevent conflicts between plans and specifications, or between different parts of the specifications, and other disciplines.

b. Cross-References. Appropriate cross-references to other sections of the specifications will be included in each section.

c. Government-Furnished Equipment. A list of equipment to be furnished by the Government and installed by the contractor will be furnished to USAEDH.